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By _____
James R. Riegel

PATENT

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Attorney Docket No.: IMM1P060.RE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re reissue application of:	
Craig F. Culver	Examiner: Unassigned
Serial No.: Unassigned	Art Unit: Unassigned
Filed: Unassigned	**REISSUE APPLICATION TRANSMITTAL**
For: INTERFACE CONTROL	

The Honorable Commissioner of Patents and Trademarks
Washington, D. C. 20231

Sir:

Transmitted herewith please find an application for the reissue of U.S. Patent No. 5,666,138, issued September 9, 1997, naming the above-identified inventor.

Enclosed are the following materials:

1. 11 pages of Specification.
2. 11 pages of Claims.
3. 1 page of Abstract.
4. 7 pages of Formal Drawings.
5. A "Reissue Declaration Under 37 C.F.R. § 1.175(a) and Power of Attorney by Inventors" signed by the inventor Craig F. Culver.
6. An "Offer to Surrender Letters Patent" together with Assignee Assent to the Declaration. It is requested that the requirement to surrender the issued patent be deferred until such time as this application for reissue is allowed. The Offer to Surrender is by the assignee.
7. A "Request for Abstract of Title and Assent of Assignee."

Amendments to the Specification and Claims are indicated with deletions in square brackets and additions underlined.

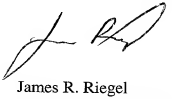
The filing fee for the above-identified reissue application has been calculated as follows.

	Number of claims filed herewith	Number of claims in Patent	Number of Extra Claims	Amount
Basic Fee	[redacted]			$ 760.00
Total Claims	73	23	50	$ 900.00
Independent Claims	5	1	4	$ 312.00
Multiple-Dependent Claims	0	[redacted]		$ 0.00
Total	[redacted]			$1972.00

A check in the amount $1972.00 is included herewith.

The Commissioner is hereby authorized to charge any additional fees to Deposit Account No. 50-0384 (Order No. IMM1P060.RE). A duplicate sheet is enclosed for accounting purposes.

Respectfully submitted,



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INTERFACE CONTROL

FIELD OF THE INVENTION

The present invention relates to an interface control. More particularly, the present invention relates to an interface control device which allows a user to control the operation of computer applications, machinery, and video games.

BACKGROUND OF THE INVENTION

Joystick controls have been employed in a wide variety of applications, including computer software, industrial machinery, and multimedia interfaces to control the positioning of an object displayed on a screen, such as a cursor or pointer. A typical prior art joystick includes a gimballed stick pivotally coupled to a flat base portion. Angle sensors coupled to the gimballed stick generate position control signals in response to a user pivoting the gimballed stick relative to the base portion. These control signals are used to manipulate the position of the cursor. A depressible switch coupled to the top of the stick is used to generate a trigger control signal for implementing various functions, such as selecting items from a pull down menu or causing a character in a video-game to jump.

The structure of these gimballed joystick controllers makes them somewhat difficult to operate. Rotating the arm and wrist to control positioning functions (i.e., pivoting the stick) while pressing downward with the thumb or finger to manipulate trigger functions requires a fair amount of practice and coordination. Further, requiring a user to simultaneously combine these motions may lead to an inadvertent change in the positioning of a cursor while implementing a trigger function. For instance, in a point-and-shoot operation, where a user first positions the cursor onto a target on the display screen and then activates the trigger function, depressing the trigger switch with the thumb or finger often results in slight movements of the arm and/or wrist, thereby causing the cursor to slip off the target. This phenomenon is commonly referred to as cursor creep.

The conventional joystick controller described above has the further disadvantage of undesirably requiring the use of two hands, i.e., one hand to hold the base of the controller and the other hand to operate the controller's stick. The only manner in which these controllers may be operated with one hand is to place the controller on a table or other flat surface.

Other joystick controllers have been developed in response to the above-mentioned problems. One such controller includes a pivoting, handgrip-shaped stick having one or more squeezable trigger switches built into a side portion of the handgrip. The positioning of an image is controlled by pivoting the handgrip, while the trigger functions are controlled by squeezing the trigger switches with the fingers. Although in such a design the positioning controls are somewhat isolated from the trigger function controls (i.e., squeezing the trigger switch with the index finger is not likely to cause as much of an inadvertent change in position as would depressing a trigger switch on the top of the stick with the thumb), cursor creep is nevertheless a problem. Further, such a controller requires the use of two hands or, alternatively, a tabletop support.

Some have attempted to develop a one-handed controller by simply reducing the size of conventional joystick controllers. These controllers fit within a user's hand, where the thumb, resting atop the stick, controls the positioning function. The trigger function is controlled by squeezing a trigger switch located on the side of the controller's stick.

These miniaturized versions of conventional joystick controllers are for the most part clumsy and ineffective. Merely

reducing the size of a controller designed for two-handed operation so as to be operated by one hand severely limits the precision with which a user may control a cursor. Further, these miniaturized controllers are ineffective in isolating trigger controls from positioning controls. Indeed, squeezing a trigger switch with, for example, the index finger typically causes the controller stick to move forward, thereby resulting in undesirable vertical cursor creep.

This undesirable interaction between positioning and trigger controls of miniature joystick controllers, coupled with users' complaints of inferior ergonomics, has led others to revert to the more primitive two-handed video game controller shown in FIG. 1. Controller 1 has four keys *2a–2d* clustered together in a first portion of controller 1 and three keys *4a–4c* grouped together in a second portion of controller 1. Keys *2a–2d* control the positioning of a displayed object (such as the hero of the video game) by generating digital positioning signals in response to a user depressing one or more of keys *2a–2d*. Keys *4a–4c* control various trigger functions (i.e., start-stop, jump, shoot, for example). The controller shown in FIG. 1, although virtually eliminating inadvertent interaction between positioning and trigger controls, nonetheless requires the use of two hands.

Thus, there is a need for joystick controller which may be operated in one hand. There is also a need for a controller having improved precision and ergonomics. Such a device should also isolate positioning and trigger controls, thereby eliminating cursor creep and other inadvertent position control signals produced during activation of trigger functions.

SUMMARY OF THE INVENTION

In accordance with the present invention, an interface control is disclosed which offers users superior performance and ergonomics. In the preferred embodiment, a thumbpiece is slidably disposed within a longitudinal arm member having a first end pivotally coupled to a fixed point. The arm member may pivot about the fixed point such that a second end portion of the arm member follows an arcuate path having as its center the fixed point. The thumbpiece slides back and forth along the longitudinal axis of the arm member. A first sensor coupled to the arm member in a region proximate to the fixed point senses the angular position of the arm member. A second sensor coupled to the thumbpiece senses the linear movement of the thumbpiece relative to and longitudinally along the arm member. A third sensor coupled to the thumbpiece senses a downward force exerted upon the thumbpiece.

The interface control may, in one embodiment, comfortably rest in the palm of a user's hand. Positioning the fingers along the underside of the interface control, a user places the thumb in the thumbpiece. The user controls the horizontal positioning of, for example, a cursor by causing the arm member to pivot either to the right or to the left about the fixed point. This motion is detected by the first sensor, which in response thereto causes the cursor to move either right or left, respectively, on a display screen. The vertical positioning of the cursor is controlled by sliding the thumbpiece along the length of the arm member. The second sensor detects this linear movement of the thumbpiece and, in response thereto, causes the cursor to move up and down on the display screen. A user may implement trigger functions by exerting a downward force on the thumbpiece. This pressure is detected by the third sensor which, in turn, causes some predetermined function to be implemented on the display screen.

In another embodiment, the longitudinal arm member is disposed within a track defining an arcuate path rather than being coupled to a fixed pivot point. In this embodiment, positioning and trigger functions are controlled in the same manner as described in the preferred embodiment. By moving the arm member along the arcuate path as defined by the track, the thumbpiece follows an arcuate path having as its center a virtual pivot point. A sensor coupled to the arm member senses the arcuate movement of the arm member relative to the interface control and in response thereto generates a horizontal positioning control signal. The vertical positioning of the cursor and trigger functions are implemented as described above in connection with the preferred embodiment.

Embodiments of the present invention isolate the trigger function from the positioning controls. The downward force used to implement a trigger function will always be orthogonal to those motions of the thumb which are used to control the positioning of the cursor, regardless of the positions of the arm member or thumbpiece. This orthogonal relationship prevents a user from inadvertently altering the positioning of the cursor when trying to implement a trigger function.

Embodiments in accordance with the present invention also achieve superior ergonomics. The arm member is preferably of a length approximately equal to that of an adult thumb where different length arm members can be provided for different size hands. Together the arm member, which rotates to form an arcuate path, and the thumbpiece, which slides along the length of the arm member, emulate the natural pivoting and curling/extending motions of the thumb, respectively. The result is a comfortable, precise, and easy to use interface control.

In another embodiment, additional trigger switches are provided within cavities formed in the underside of the interface control. The fingertips of the user's hand, each comfortably nestled within an associated cavity, control the operation of the additional trigger switches, which may be used to implement numerous other functions.

Embodiments of the present invention are usable as an interface between a user and a machine where the machine carries out some predetermined function in response to commands issued by the user. In one embodiment, for instance, the user may control the mechanical operation of construction equipment. In another embodiment, the user may control moveable elements on a display screen, such as a cursor in a software application or an object in a video game.

This invention will be more fully understood in view of the following description taken together with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a prior art four-key cluster joystick controller;

FIG. 2 is a plan view of one embodiment in accordance with the present invention;

FIGS. 3A and 3B are side and end views of the embodiment of FIG. 2, respectively;

FIG. 4 is a perspective view of a portion of the embodiment of FIG. 2;

FIG. 5 shows one embodiment in accordance with the present invention resting in the palm of a user's hand;

FIG. 6 shows another embodiment in accordance with the present invention;

FIG. 7 is an end view of another embodiment in accordance with the present invention;

FIG. 8 is a plan view of yet another embodiment in accordance with the present invention;

FIG. 9 shows the embodiment of FIG. 2 used in conjunction with the prior art controller of FIG. 1; and

FIGS. 10, 11 and 12 are plan views of three other embodiments in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the present invention, an interface control is disclosed which allows a user to simultaneously control both a trigger function and the positioning of a cursor through a single contact surface using only the thumb. In the preferred embodiment shown in FIGS. 2, 3A, 3B, 4 and 5, a hand-held interface control **10** is provided in support **12** which includes base plate **14** and side wall **16** having first rounded end portion **16***a*, second rounded end portion **16***b*, and side portions **16***c*, **16***d* connecting rounded end portions **16***a*,**16***b*. Top plate **18** (FIGS. 3A and **3B**) is provided above side wall **16** and encloses a portion of support **12**. Longitudinal arm member **20** (FIGS. 2, 3A, 3B, 4, 5) is disposed in and pivotally connected to support **12** (FIG. 2) at point **22**. Arm member **20** may be connected to support **12** by any suitable means, such as bolt **23** (FIGS. 2, 3A, 3B, 4, 5), or an appropriate bearing surface which allows arm member **20** to pivot about point **22** as indicated by arrows **25***a*, **25***b* (FIG. 2). As will be explained below, the resistance provided between (1) arm member **20** and base plate **14** and (2) thumbpiece **28** and arm member **20** may be adjusted to a level suitable to the needs of a particular user or application.

First sensor **26** (FIGS. 2, 3A, 3B) is coupled to arm member **20** and senses the angular rotation of arm member **20** about point **22**. First sensor **26**, preferably a rotary resistive potentiometer although other appropriate sensing structures such as capacitive sensors, for example, can also be used, generates first positioning signals indicative of the direction and magnitude of arm member **20**'s rotation about point **22**.

Referring to FIGS. 3A and 4, arm member **20** has cavity **30** formed at one end thereof. Cavity **30** is bounded on either side by side walls **20***a*, **20***b* which have formed therein grooves **34***a*, **34***b* (groove **34***b*, which is formed within side wall **20***b*, is not shown in FIG. 4).

Thumbpiece **28** (FIGS. 2, 3A, and 4) is slidably mounted within cavity **30** of arm member **20** and may slide along the length of arm member **20**, as indicated by arrows **32***a*, **32***b* (FIG. 2). Outwardly protruding flanges **36***a*, **36***b* (FIG. 4) provided on the sides of thumbpiece **28** matingly couple with grooves **34***a*, **34***b* formed in side walls **20***a*, **20***b*, respectively, of arm member **20** to facilitate the sliding of thumbpiece **28** along the length of arm member **20**. Curved contact surface **38**, which is provided on a top surface of thumbpiece **28**, engages the thumb of a user operating hand-held interface control **10** (FIGS. 2, 3A, and 3B).

Shaft **40** (FIGS. 2, 3A) has a first end fixably mounted to a bottom surface of thumbpiece **28** and a second end slidably disposed within second sensor **42**. Second sensor **42**, which is disposed within arm member **20**, detects the linear movement of shaft **40** (and thus the linear movement of thumbpiece **28**) relative to sensor **42** and generates second positioning signals indicative of the position of thumbpiece **28** relative to arm member **20**.

Second sensor **42** is preferably a linear resistive potentiometer. If a rotary potentiometer is used as second sensor **42**, thumbpiece **28** may be coupled to the potentiometer by a conventional rack and pinion gear. It is to be understood,

however, that any other sensing device capable of detecting either motion or pressure may be used as first sensor **26** and second sensor **42** in interface control **10**. Although first sensor **26** and second sensor **42** preferably produce analog positioning signals, interface control **10** may also employ sensors which produce digital positioning signals.

A third sensor **44** (FIG. 3A) is secured to a bottom surface of arm member **20** so that third sensor **44** moves with arm member **20** about point **22** (FIG. **2**). A bottom surface of third sensor **44** is in contact with and slides along (when arm member **20** pivots about point **22**) a top surface of base plate **14** (FIG. 3A). When a user exerts a downward pressure upon thumbpiece **28**, third sensor **44** engages base plate **14** and in response thereto generates a trigger control signal. Third sensor **44** may be any conventional pressure sensitive device which converts a pressure into an electric signal. In one embodiment, third sensor **44** is a microswitch of well known design.

A user cradles hand-held interface control **10** in the palm of his or her hand, positioning his fingers along the underside of bottom plate **14** and resting his thumb on curved contact surface **38** of thumbpiece **28**, as shown in FIG. **5**. Using only his thumb, the user may control the horizontal and vertical positioning of, for instance, a cursor on a display screen, as well as implement various related functions (such as selecting options from a pull-down menu).

The horizontal positioning of the cursor is manipulated by pivoting arm member **20** about point **22**, whereby arm member **20** traces an arcuate path as indicated by arrows **25***a*, **25***b* (FIG. **2**). First sensor **26**, in response to the arcuate motion of arm member **20**, generates a first positioning signal which controls the horizontal positioning of a cursor on a display screen indicative of the angular position of arm member **20**. For instance, to move the cursor to the right on the display screen, the thumb (resting in thumbpiece **28**) is used to move arm member **20** in an arcuate path to the right, as indicated by arrow **25***a*.

Preferably, arm member **20** is of a length (measured between portions **16***a* and **16***b* of side wall **16**) approximately equal to that of the user's thumb so that when a user places the thumb on contact surface **38** of thumbpiece **28**, the user's large thumb joint is immediately above point **22**. The length of arm member **20** may be of varying lengths so as to accommodate different size hands. As discussed above, arm member **20**, pivoting about point **22**, travels in an arcuate path between sidewalls **16***a*, **16***b* of interface control **10**. This arcuate path emulates the natural motion of the thumb as it pivots about the large thumb joint, thereby resulting in a natural and ergonomic relationship between the thumb and arm member **20**. Hence, interface control **10** uses the natural arcuate motion of a user's thumb to effect linear changes in the horizontal positioning of a cursor on the display screen.

The vertical positioning of the cursor is controlled by sliding thumbpiece **28** along the length of arm member **20** as indicated by arrows **32***a*, **32***b* (FIG. **2**). Second sensor **42** detects the linear movement of thumbpiece **28** and, in response thereto, generates second positioning signals which control the vertical positioning of the cursor. For instance, to move the cursor up or down on a display screen, the user simply uses his or her thumb to move thumbpiece **28** away from or towards point **22**. This movement is easily achieved by extending or curling the thumb. Note that by positioning the fingers on the bottom side of base plate **14**, the combined movement of the fingers assist the thumb in the curling and extending motions.

Trigger functions are implemented by exerting a downward pressure (using the thumb) upon thumbpiece **28**. Third sensor **44** senses this downward pressure and, in response thereto, generates a trigger control signal. Depending upon the particular application with which interface control **10** is being used, this trigger control signal may implement a variety of functions. For instance, in computer software or interactive systems, this trigger control may select items from a menu. When used with a video game, for example, this trigger control may cause a character to jump.

The downward pressure exerted by the thumb to implement a trigger control signal is always orthogonal to the thumb motions used to control horizontal and vertical positioning, regardless of the angular position of arm member **20** or the linear position of thumbpiece **28**. This orthogonal relationship eliminates undesirable interaction between the trigger control and the positioning controls and thus prevents cursor creep. A user, when exerting a downward pressure on thumbpiece **28**, is not likely to inadvertently pivot or extend/curl the thumb (which would cause a change in the positioning of the cursor). Thus, by isolating the trigger and positioning controls, as described above, interface control **10** provides advantages over conventional joystick controllers which suffer from cursor creep problems.

FIG. **6** shows another embodiment of the present invention. Interface control **50**, the operation of which is identical to that of interface control **10**, includes all the components of interface control **10** plus additional features described below. Interface control **50** includes two groups of cavities **52***a*, **52***b*, and **52***c* and **54***a*, **54***b*, and **54***c* formed in the bottom surface of base plate **14**. When a user cradles interface control **50** in the left hand, the tips of the three fingers closest to the thumb may comfortably rest within associated cavities **52***a*–**52***c*. Each of cavities **52***a*, **52***b*, and **52***c* has an associated switch **56***a*, **56***b*, **56***c*, respectively, disposed therein so that each of the user's fingers may activate one of associated switches **56***a*, **56***b*, **56***c* while holding interface control **50**. Switches **56***a*, **56***b*, **56***c*, when depressed by the user's finger tips, generate second, third, and fourth trigger control signals, respectively, for implementing additional predetermined functions.

In a similar manner, a right-handed user may place one of the three fingers closest to the thumb (of the right hand) in each of cavities **54***a*, **54***b*, and **54***c* to operate associated switches **58***a*, **58***b*, **58***c*, which, like switches **56***a*, **56***b*, **56***c*, generate second, third, and fourth trigger control signals, respectively, for implementing various predetermined functions.

If additional control signals are desired for implementing even more predetermined functions, control circuitry may be added so that the simultaneous depression of two of more switches **56***a*, **56***b*, **56***c* (or **58***a*, **58***b*, **58***c* for right-handed users) generate these additional control signals. For instance, simultaneously depressing switches **56***c* and **56***b* (for left-hand operation) or **58***c* and **58***b* (for right-hand operation) may generate a fifth trigger control signal.

FIG. **7** is an end view of another embodiment in accordance with the present invention. Interface control **60**, which operates in a manner identical to interface control **10** (FIGS. 2, 3A, 3B, 4, and 5), includes a plurality of first detents **61** formed on the top surface of base plate **14**. One second detent **62** is provided on the bottom surface of arm member **20** such that as arm member **20** pivots about point **22** (not shown), second detent **62** moves between pairs of the plurality of first detents **61**. Arm member **20** may preferably come to rest only at those positions where second detent **62**

is positioned between a pair of first detents **61**, thereby providing arm member **20** with a discrete number of click stops. These click stops may add increased stability and control to the positioning controls of interface control **60**.

The embodiments in accordance with the present invention are advantageous over conventional joystick controllers. Indeed, interface controls **10** and **50** are suitable for one-handed operation, thereby leaving the user's other hand free to perform other tasks. This one-handed operation also eliminates the need for a flat surface, as required when using a mouse or operating conventional joystick interface controls with one hand.

Using the thumb to control positioning functions contributes to the superior ergonomics of interface controls **10** and **50**. As mentioned above, conventional joystick controllers require various combinations of wrist and arm movements to control the positioning of a cursor and additional finger or thumb motions to control trigger functions. Such unnatural combinations of motions necessitate training and practice in order for a user to become proficient. This is especially true as the size of such a control is reduced. Unlike conventional controllers, embodiments in accordance with the present invention (1) isolate the horizontal and vertical positioning functions from each other and (2) isolate the positioning functions from the trigger functions while simultaneously allowing both functions to be controlled by a single user contact point. The result is an interface control which allows users to issue vertical and horizontal positioning commands in concert for smooth and precise motions along both axes (i.e., a diagonal motion), as well as implementing trigger functions without inadvertently altering those positioning commands. Further, the interface controls described herein allow users to control both positioning and trigger control functions with simple, intuitive thumb motions.

When a user traces his or her thumb across the tips of the fingers, every joint in his or her hand moves in concert to facilitate the thumb's motion. This opposed position of a user's thumb relative to his or her fingers and palm is utilized by interface controls **10** and **50** to achieve a comfortable and natural interface between the user and a machine (such as a computer). Indeed, by positioning a user's fingers along the bottom surface of base plate **14** and his or her thumb in thumbpiece **28**, interface controls **10** and **50** operate in a manner consistent with the thumb's natural motions. By taking advantage of the thumb's full arcuate motion about the large thumb joint and the thumb's excellent linear motion, interface controls in accordance with the present invention allow a user to quickly and easily position a cursor or pointer on a display screen. The superior ergonomics of the above interface controls afford users a high degree of precision and efficiency without the extensive practice and training required of conventional joystick controllers. This accuracy and ease of use makes the present interface controls especially well suited for CAD or any other computer illustration systems.

The frictional coupling between elements of the preferred embodiments may be manipulated to adjust the "feel" of interface controls **10** and **50**. For instance, contact surface **38** (FIGS. 4 and 8) of thumbpiece **28** may be shaped with respect to the top surfaces of sidewalls **20***a*, **20***b* so that the sides of a user's thumb are in frictional contact with sidewalls **20***a*, **20***b*. This frictional contact may increase the stability with which thumbpiece **28** slides along arm member **20**, thereby increasing the accuracy of vertical positioning of a cursor.

In a similar manner, the frictional coupling between third sensor **44** (FIG. 3A) and the top surface of base plate **14** of

housing 12 may be adjusted to increase the accuracy of the horizontal positioning control of interface controls **10** and **50**. For example, a strip of Teflon material (not shown) may be provided between third sensor **44** and bottom plate **14** to achieve a desirable "silky" feel when a user pivots arm member **20** about point **22** (FIG. 4). The Teflon causes drag to progressively increase as thumbpiece **28** is depressed, without any significant increase in static friction. This resultant increase in drag contributes to an increased stability in performing drag-select operations in which the trigger switch is depressed while the cursor is moved from a first position to a second position (as in highlighting text in word processing programs).

FIG. 8 shows another embodiment in accordance with the present invention. Interface control **65** includes arm member **29** slidably disposed on conventional curved guide tracks **64***a*, **64***b* within support **67**. Tracks **64***a*, **64***b* define an arcuate path having as its center virtual pivot point **66**. Arm member **29** slides along this arcuate path as indicated by arrows **25***a*, **25***b* as if arm member **29** were pivoting about virtual pivot point **66**. Disposing arm member **29** within tracks **64***a*, **64***b* in this manner eliminates the need for arm member **29** to be coupled to a fixed pivot point, as is arm member **20** of interface control **10** (FIGS. 2, 3A, 3B, 4, and 5), and therefore allows for interface control **65** to be of a significantly smaller size. Thumbpiece **28** is slidably disposed within arm member **29** and slides along the length of arm member **29** as indicated by arrows **32***a*, **32***b*.

The positioning and trigger functions of interface control **65** are controlled in a manner identical to those of interface control **10** as described above (see FIGS. 2, 3A, 3B, 4, and 5) and will thus not be described here. Interface control **65** possesses all of the advantages discussed above with respect to interface control **10**, including allowing users to control the operation of applications with simple and intuitive motions that closely emulate the natural motions of the human thumb and isolates positioning controls (1) from each other and (2) from trigger controls as described above. Likewise, interface control **65** may be also be provided with the friction coupling and feedback features described above.

The embodiments described above may be used in virtually any application which requires an interface control between a user and a machine. Embodiments in accordance with the present invention may be used to control the operation of a construction crane or boom. Interface controls **10** and **50** are ideal for replacing the mouse or trackball in computer software applications such as word processing, databases, and spreadsheets. For instance, interface control **50** of FIG. 6 (see also FIGS. 2, 3A, 3B, 4, and 5) is well suited for use with video games. As described above, thumbpiece **28** may be used to control the positioning of a character in the video game. By depressing thumbpiece **28** so as to activate third sensor **44**, the user may implement various predetermined functions, such as starting/stopping the game and selecting game options. Switch **56***a* (**58***a* for right-handed users) may, for instance, cause the character to jump. Switch **56***b* (**58***b*) may cause the character to fire a bullet, and so on.

Embodiments of the present invention may also be incorporated into conventional two-handed video game controllers (see FIG. 1) to provide a superior video game interface control. For example, positioning control keys **2***a*, **2***b*, **2***c*, and **2***d* (FIG. 1) may be replaced by interface control **10**, as illustrated in FIG. 9. Two-handed video game controller **90** has disposed within a first portion thereof a portion of interface control **10** of FIGS. 2, 3A, 3B, and 4. For purposes of clarity, not all of the components of interface control **10**

are labelled. Arm member **20** and thumbpiece **28** control the positioning of objects (i.e., characters of a video game) displayed on a screen in the same manner as described previously with reference to FIGS. **2**, **3A**, **3B**, and **4**, while keys **4***a*, **4***b*, and **4***c* implement various trigger functions.

The above described interface controls may be mounted in virtually any enclosure, including (but not limited to) control panels, automobile dashboards, steering wheels, or handgrips of other interface controls. For instance, in one such embodiment, base plate **14** (FIG. **2**) may be disposed within the handgrip portion of a floor-mounted lever arm control, i.e., a transmission selector in a vehicle, to provide users with a superior means to control such things as the vehicle's navigation system or communications with the vehicle's on-board computer system.

In another embodiment, interface controls in accordance with the present invention may be disposed within a control panel such as the dashboard of an automobile, boat, or even an airplane to provide control over certain operations. For example, interface control **10** may be mounted in the control panel of construction equipment to control the operation of a boom or crane. A control panel-mounted interface control **10** could also be used to manually control, for instance, the processing operations of an industrial application or the positioning and firing of lasers in medical applications. These embodiments, like those discussed above, are advantageous since multiple control functions (**1**) are disposed on a single contact surface and (**2**) are isolated from one another.

Some of the ergonomic advantages discussed herein may be compromised in order to provide a user interface control capable of controlling positioning in three, rather than two, directions. In one such embodiment in accordance with the present invention, various elements of interface control **10** may be incorporated into the handgrip of a conventional full-size joystick to provide three-dimensional positioning control as well as trigger functions.

FIG. **10** shows interface control **70** including gimballed stick **72** having formed at one end an inclined, elongated upper portion **74**. Formed within top surface **76** of upper portion **74** is secondary interface control **80** which includes all the features of and operates in a similar manner to interface control **10** (FIGS. **2**, **3A**, **3B**, and **4**). Secondary interface control **80** preferably has thumbpiece **28** fixably mounted within arm member **20** so that thumbpiece **28** may not slide along arm member **20**, thereby eliminating the need for second sensor **42** as well as grooves **34***a*, **34***b* and flanges **36***a*, **36***b* (FIG. **4**). The other end of stick **72** (FIG. **10**) is pivotally mounted to a base portion (not shown) having sensors which generate first and second positioning signals in response to stick **72** pivoting with respect to the base portion, as discussed above in reference to conventional joystick controllers.

A user curls the four fingers of his or her hand around stick **72** and places the thumb in thumbpiece **28** (FIG. **10**). The user controls the horizontal and vertical positioning of, for instance, a cursor displayed on a CRT in a conventional manner as described above, i.e., by pivoting stick **72** about the base portion. The user controls fin depth positioning of the cursor with the thumb by pivoting arm member **20** about pivot point **22** (see FIG. **2**). Trigger functions are activated by pressing downward on thumbpiece **28** (as discussed in reference to interface control **10**).

Various forms of feedback may be added to the above described embodiments to provide a user with additional information about the particular application he or she is

controlling, as described below in reference to FIGS. 11 and 12. For instance, arm member 20 of interface control 10 (FIGS. 2, 3A, 3B, and 4) may be fitted with a first actuator that in response to a first feedback signal prevents arm member 20 from further pivoting in one or both directions or, in the alternative, alters the frictional contact between arm member 20 and base plate 14 so as to alter the ease with which arm member 20 pivots.

Referring to FIG. 11, interface control 80, the operation of which is identical to that of interface control 10, includes all of the components of interface control 10 plus additional features described below. For purposes of clarity, not all of the components of interface control 80 common with those of interface control 10 are shown. Arm member 20 of interface control 80 has coupled thereto electromagnetic coil 82 which, in turn, is wound around a conventional ferrous core (not shown). Shaft 84 extends along arm member 20 and has a first end matingly coupled to surface 86 of sidewall 16b. A second end of shaft 84 extends through coil 82 and is coupled to iron armature 88. Armature 88 is preferably positioned as close to coil 82 as possible. When a first feedback current is provided to coil 82, the resultant magnetic field produced by coil 82 attracts armature 88 towards coil 82, thereby causing the first end of shaft 84 to shift towards and press against surface 86 of sidewall 16b. The resultant increase in frictional coupling between arm member 20 and sidewall 16b resists any pivoting movement of arm member 20 about point 22. In other words, coil 82, shaft 84, and armature 88 act as a magnetically activated brake. Varying levels of feedback current will result in proportionally varying levels of drag. This brake may be implemented to simulate detents, stops, or other forms of reflective feedback.

In a similar manner, a second actuator may be provided that in response to a second feedback signal inhibits the movement of thumbpiece 28 along arm member 20, as illustrated in FIG. 12. Arm member 20 has provided therein a sliding bar 90 having a first end coupled to thumbpiece 28. Iron core 92 is coupled to arm member 20 and is positioned in a region proximate to a second end of bar 90. Magnetic coil 94 is wound around ferrous core 92. A second feedback current provided to coil 94 will induce a magnetic attraction between bar 90 and against core 92, thereby resulting in an increased frictional coupling between bar 90 and core 92. This increased frictional coupling resists the sliding motion of thumbpiece 28 along arm member 20. Note that in some embodiments shaft 40 (FIG. 3A) (not shown in FIG. 12 for simplicity) may also serve the same function as bar 90 in addition to being part of the longitudinal sensing structure of arm member 20.

The embodiments described above and illustrated in FIGS. 11 and 12 would, for instance, be especially well suited for use with applications in which it is desirable to preclude a user from selecting certain options or moving a cursor into certain areas. In a video game application, for instance, the game's character may be precluded from entering a restricted area of the displayed image. The video game may issue feedback signals as discussed above to preclude the user from causing the character to move into the restricted areas. Thus, the feedback signals, by restraining or even preventing (1) arm member 20 from pivoting about point 22 and/or (2) thumbpiece 28 from sliding along arm member 20 directly inform the user he can no longer move in that direction. In a similar manner, an additional actuator may be contained within third sensor 44 (see FIG. 3A) to preclude activation of trigger functions at certain predetermined character positions. Unlike conventional interface

control feedback systems which use flashing lights or sounds to warn users of an improper selection or movement, the direct force-reflecting feedback described above, by preventing the user from effecting certain positioning commands, provides a realistic feel to video games and other applications.

In other applications, interface control **80** (FIG. **11**) may be used to facilitate the selection of options or icons. As the user moves the cursor or pointer over an icon displayed on a screen, feedback signals generated by the application may simulate a detent by increasing the frictional coupling between arm member **20** and sidewall **16**b and between thumbpiece **28** and arm member **20**, as described above with reference to FIGS. **11** and **12**, when the cursor or pointer is positioned near or overlaps certain icons displayed on the screen. This simulated detent varies the amount of force the user must exert to effect further positioning changes in certain directions, i.e., the detent may either make it easier or harder for the user to cause the cursor to pass across the icon. In this manner, the user can "feel" when he or she has reached a particular icon (or any other specific screen location). This simulated detent may be deactivated when, for instance, the icon has been selected or when the cursor has passed over the icon.

The actuators discussed above may comprise a solenoid, a servomotor, or any other suitable device known in the art which generates a force in response to electric signals. The actuators may also employ shape-memory alloys, piezo ceramics, or electro-rheological compounds. Further, motor-type actuators may be employed to augment or restrain motion.

In other embodiments, the actuators discussed above may used to activate and deactivate electrically controlled detents so as to provide tactile click stops in the pivoting motion of arm member **20** (FIG. **2**) about point **22** or in the linear motion of thumbpiece **28** along arm member **20**. These detents may be logically correlated with specific targets or options on a display screen such that once a particular option is selected, its corresponding detent is electrically deactivated. Adaptive feedback of this type can be very effective in making the above-described controls more intuitive.

Embodiments of the present invention may also be equipped with a spring return mechanism. With reference to interface control **10** (FIG. **2**), a centering spring may be coupled to arm member **20** which causes arm member **20** to return to its center position whenever arm member **20** has deviated from the center position by exerting pressure on arm member **20**. A manually controlled latch may also be provided which engages the centering spring to and disengages the centering spring from arm member **20** so as to turn on and off the centering mechanism. Such a centering mechanism is useful in applications requiring proportional control (i.e., a conventional joystick) rather than absolute control (i.e., a mouse). The centering spring may also be electrically actuated by an external signal from the interfaced device (i.e., computer, video game, and so on). Incision of such an electrically actuated spring allows the interfaced device to switch the controller between two modes of operation (spring centering and non-centering), as the particular application may require. In a similar manner, an additional centering spring may be coupled to thumbpiece **28** to provide proportional control in the vertical direction.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be

made without departing from this invention in its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. An apparatus for generating at least two control signals, said apparatus comprising:

a support;

an arm member disposed within said support, said arm member being moveable in an arcuate path within said support;

a contact member slidably mounted on said arm member, said contact member being slidable along said arm member;

a first sensor coupled to said arm member for sensing movement of said arm member along said arcuate path; and

a second sensor coupled to said contact member for sensing linear movement of said contact member along said arm member.

2. The apparatus of claim 1 further comprising:

first guide means disposed along said arm member; and

second guide means disposed on said contact member, said second guide means matingly coupled with said first guide means so as to facilitate the movement of said contact member along said arm member.

3. The apparatus of claim 2 wherein said first guide means comprise first and second grooves horizontally disposed in first and second side walls, respectively, of said arm member, said second guide means comprising first and second flanges disposed on first and second side walls of said contact member, respectively.

4. The apparatus of claim 1 wherein said arm member is pivotally coupled to said support at a pivot point, said arm member moving in said arcuate path as said arm member pivots about said pivot point.

5. The apparatus of claim 1 further comprising:

a track means disposed within said support, said track means defining said arcuate path; and

one or more guide elements disposed on an outer surface of said arm member, said one or more guide elements being matingly coupled to said track means for facilitating the movement of said arm member in said arcuate path.

6. The apparatus of claim 1 wherein said first sensor detects the magnitude and direction of arcuate movement of said arm member along said arcuate path and generates a first control signal in response thereto.

7. The apparatus of claim 1 wherein said second sensor detects the magnitude and direction of linear movement of said contact member and generates a second control signal in response thereto.

8. The apparatus of claim 1 further comprising a third sensor coupled to said arm member, said third sensor detecting a downward pressure on said contact member and in response thereto generating a signal for implementing a first predetermined function.

9. An apparatus for generating at least two control signals, said apparatus comprising:

a support;

an arm member having a first end portion pivotally coupled to said housing at a point, said arm member being rotatable about said point;

a contact member slidably mounted on said arm member, said contact member being slidable along said arm member;

a first sensor coupled to said arm member for sensing arcuate movement of said arm member; and

a second sensor coupled to said contact member for sensing linear movement of said contact member along said arm member.

10. The apparatus of claim **9** wherein said support is of a size such that said apparatus is capable of being operated with one hand of a person.

11. The apparatus of claim **9** wherein said first sensor generates a first control signal representing the angle and direction of rotation of said arm member, said first control signal being capable of being used to alter the position of a cursor or pointer in a first direction on a display screen.

12. The apparatus of claim **9** wherein said second sensor generates a second control signal representing the magnitude and direction of linear movement of said contact member, said second control signal being capable of being used to alter the position of a cursor or pointer in a second direction on a display screen.

13. The apparatus of claim **9** further comprising a third sensor disposed on said arm member, said third sensor detecting a downward pressure on said contact member.

14. The apparatus of claim **13** wherein said third sensor generates a third control signal indicative of said downward pressure on said contact member, said third control signal implementing a first predetermined function.

15. The apparatus of claim **9** further comprising a first actuator, wherein in response to a first feedback signal said first actuator restrains said rotation of said arm member.

16. The apparatus of claim **15** wherein said first actuator is contained within said first sensor.

17. The apparatus, of claim **15** further comprising a second actuator, wherein in response to a second feedback

signal said second actuator restrains the linear movement of said arm member.

18. The apparatus of claim 17 wherein said second actuator is contained within said second sensor.

19. The apparatus of claim 9 wherein said contact member has a concave upper surface so that a human thumb may matingly situate on said contact member.

20. The apparatus of claim 9 wherein said arm member has disposed therein one or more first guide means, said contact member having disposed thereon one or more second guide means, each of said first guide means being matingly coupled with an associated one of said second guide means for facilitating sliding of said contact member along said arm member.

21. The apparatus of claim 20 wherein said first guide means comprise first and second grooves horizontally disposed in first and second side walls, respectively, of said arm member, said second guide means comprising first and second flanges disposed on first and second side walls of said contact member, respectively.

22. The apparatus of claim 9 wherein said housing has a bottom surface, said apparatus further comprising:

one or more cavities formed in said bottom surface of said housing;

one or more switches, each of said switches being associated with and coupled to an associated one of said cavities.

23. The apparatus of claim 22 wherein said switches comprise pressure sensitive devices, the actuation of which generates one or more fourth control signals for implementing one or more second predetermined functions.

* * * * *

✓24. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a display device, said device comprising:

a support housing able to be held by a hand of a user;

a user manipulatable member engageable and moveable by a thumb of said user in two dimensions relative to said support housing while said support housing is held by said hand of said user, wherein said movement in said two dimensions positions said cursor in two screen dimensions on said display device;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two dimensions, said sensor providing positioning signals which control said positioning of said cursor on said display device;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in at least one of said dimensions of said user manipulatable member, wherein said force facilitates the selection of options or icons displayed on said display device based on feedback signals generated by an application running on said computer; and

a trigger sensor for detecting a trigger command from said user, said trigger command including moving said user manipulatable member approximately orthogonally to said two dimensions.

25. A force feedback device as recited in claim 24 wherein said two dimensions are provided substantially in a single plane.

26. A force feedback device as recited in claim 25 wherein said motion of said user manipulatable member is orthogonal to a plane defined by said planar dimensions.

27. A force feedback device as recited in claim 24 wherein said at least one actuator is a first actuator, and further comprising a second actuator coupled to said user manipulatable member, wherein said second actuator provides a force in the other of said dimensions of said user manipulatable member.

28. A force feedback device as recited in claim 24 wherein said user manipulatable member is coupled to an arm member having rotary motion about a pivot point to provide motion in one of said two dimensions, wherein said actuator is coupled to said arm member to output forces about said pivot point.

29. A force feedback device as recited in claim 28 wherein said rotary motion of said arm member is limited to an arcuate path of less than ninety degrees.

30. A force feedback control device as recited in claim 28 further comprising a second actuator, and wherein said first actuator is grounded to said housing and wherein said second actuator is carried by said arm member.

31. A force feedback device as recited in claim 28 wherein said user manipulatable member is a sliding contact member which can be moved in a linear dimension approximately perpendicular to an axis of rotation of said arm member and in substantially the same plane as said rotary motion, thereby providing said motion in one of said two dimensions.

32. A force feedback device as recited in claim 24 wherein said cursor can be positioned and displayed icons or options can be selected by a single hand of said user.

33. A force feedback device as recited in claim 24 wherein said at least one actuator is one of a motor, a brake, and a solenoid.

34. A force feedback device as recited in claim 24 wherein said user manipulatable member is coupled to a centering spring return that causes a bias on said user manipulatable member to return to a center position after it has been moved from said center position.

35. A force feedback device as recited in claim 24 wherein a centering spring bias on said user manipulatable member may be electrically actuated by a signal received from said computer, allowing said force feedback device to have a centering mode and a non-centering mode, selected by said computer.

36. A force feedback device as recited in claim 24 wherein said cursor can be used to select an icon, wherein said trigger command selects said icon when said cursor is positioned over said icon.

37. A force feedback device as recited in claim 36 wherein said at least one actuator outputs a force to augment or restrain motion of said cursor on said screen.

38. A force feedback device as recited in claim 24 wherein said image is a video game character.

39. A force feedback device as recited in claim 24 further comprising a trigger actuator for causing resistance to said motion of said trigger command by said user based on a feedback signal from said computer.

40. A force feedback device as recited in claim 24 further comprising at least one additional control provided on said housing and operable by said user, wherein said additional control is operated by a different hand of said user than said hand operating said user manipulatable member.

41. A method as recited in claim 24 wherein said at least one actuator outputs detents when said cursor overlaps or is positioned near an icon displayed on said screen.

42. A method as recited in claim 41 wherein detents provide tactile click stops correlated with targets or options displayed on said screen.

43. A method as recited in claim 42 wherein a detent correlated with a target or option is deactivated once said target or option is selected by said user using said force feedback device.

44. A method as recited in claim 41 wherein said user selects said target or option by causing a trigger signal to be sent to said computer, said trigger signal caused by a pressing motion of said user manipulatable member.

45. A method as recited in claim 41 wherein said detents are output for use in a word processor or spreadsheet program provided on said computer.

√46. A force feedback device coupled to a computer for providing positioning signals to said computer for manipulating an image displayed on a screen by said computer, said device comprising:

a support housing;

a user manipulatable member coupled to said housing and engageable and moveable by one or more digits of said user in two degrees of freedom relative to said housing, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said sensor providing positioning signals which control positioning of said image on said screen by said computer;

at least one computer controlled brake coupled to said user manipulatable member, wherein said brake provides a drag in at least one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion by said digit causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

47. A force feedback device as recited in claim 46 wherein said housing is able to be held and operated by a single hand of a user.

48. A force feedback device as recited in claim 46 wherein the other of said two degrees of freedom is a linear degree of freedom and wherein said rotary degree of freedom allows a pivoting motion of said digit of said user.

49. A force feedback device as recited in claim 47 wherein said two degrees of freedom are approximately in the same plane.

50. A force feedback device as recited in claim 46 wherein said at least one brake is a first brake providing a drag in a first of said two degrees of freedom, and further comprising a second computer controlled brake coupled to said user manipulatable member, wherein said second brake provides a drag in a second one of said degrees of freedom of said user manipulatable member.

51. A force feedback device as recited in claim 50 wherein said user manipulatable member is coupled to an arm member having rotary motion about a pivot point, wherein said first brake is coupled to said arm member to output forces about said pivot point.

52. A force feedback device as recited in claim 51 wherein said user manipulatable member is a sliding member which can be moved along at least a portion of said arm member in a linear degree of freedom, and wherein said second brake outputs forces in said linear degree of freedom.

53. A force feedback device as recited in claim 46 wherein said cursor can be used to select an icon displayed on said screen, wherein said trigger command selects said icon when said cursor is positioned over said icon.

54. A force feedback device as recited in claim 46 wherein said brake outputs a force controlled by said computer to provide tactile clicks correlated with targets or options displayed on said screen.

55. A force feedback device as recited in claim 46 wherein said device is provided in an automobile dashboard or automobile steering wheel.

56. A force feedback device as recited in claim 46 wherein said at least one brake includes an electromagnetic coil.

57. A force feedback device as recited in claim 46 wherein said at least one brake employs an electro-rheological compound.

58. A method for providing positioning signals to a computer from a user for manipulating a displayed cursor on a screen and for providing force feedback to said user, said method comprising:

providing a handheld force feedback device coupled to said computer, said handheld force feedback device including a thumb member engageable and moveable by a thumb of said user in two degrees of freedom while said device is held by said hand of said user;

sensing movement of said thumb member in said two degrees of freedom using at least one motion sensor and providing positioning signals to said computer in accordance with said sensed movement, wherein said positioning signals are used by said host computer to move a cursor displayed on a screen in two dimensions of said screen; and

providing a drag in said two degrees of freedom of said thumb member using at least one braking actuator coupled to said thumb member, wherein said drag facilitates selection of an icon or option displayed on said screen by said cursor.

59. A method as recited in claim 58 further comprising detecting a trigger command from said user, said trigger command including a pressing motion of said

thumb member, wherein said trigger command is sent to said computer to be used to select an option or icon displayed on said screen with said cursor.

60. A method as recited in claim 58 wherein said two degrees of freedom are substantially in a single plane.

61. A method as recited in claim 58 wherein one of said degrees of freedom is a rotary degree of freedom and another of said degrees of freedom is a linear degree of freedom.

62. A method as recited in claim 58 wherein said brakes output drag to hinder motion of a rotating member coupled to said thumb member and hinder a sliding motion of said thumb member.

63. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a screen, said device comprising:

a support housing;

a user manipulatable member coupled to said housing and engageable and moveable by a digit of said user in two degrees of freedom relative to said housing while said housing is held by said hand of said user, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

a spring return mechanism coupled to said user manipulatable member to provide a centering bias on said user manipulatable member toward a center position of said rotary degree of freedom when said user manipulatable member has been moved from said center position;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said sensor providing positioning signals which control said positioning of said cursor on said screen;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

64. A force feedback device as recited in claim 63 wherein said spring return mechanism is electrically actuated by an external signal received from said computer, allowing said spring return mechanism to be selectively applied in a centering mode and allowing said spring return mechanism to have no effect in a non-centering mode.

65. A force feedback device as recited in claim 64 wherein said external signal is controlled by a video game running on said computer.

66. A force feedback device as recited in claim 64 wherein said spring return mechanism is coupled to a pivotable arm member providing said rotary degree of freedom, and further comprising a centering spring coupled to said user manipulatable member to provide a centering bias in another of said two degrees of freedom.

67. A force feedback control provided in an automobile and coupled to an on-board vehicle computer system for providing input to said computer system, said control comprising:

a user manipulatable member provided in an automobile dashboard, said member engageable and moveable by a digit of said user in two degrees of freedom relative to said dashboard, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said input to said computer system based on positioning signals provided by said sensor;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

68. A force feedback control as recited in claim 67 wherein said user manipulatable member is manipulated by said user to provide communication with said on-board computer system.

69. A force feedback control as recited in claim 67 wherein said input to said computer system controls a vehicular navigation system.

70. A force feedback control as recited in claim 67 wherein said two degrees of freedom of said user manipulatable member define a plane.

71. A force feedback control as recited in claim 67 wherein said trigger degree of freedom is orthogonal to said plane.

72. A force feedback control as recited in claim 67 wherein said actuator is a motor.

73. A force feedback control as recited in claim 67 wherein said actuator is a passive brake.

[57] **ABSTRACT**

An improved interface control advantageously may be operated by one hand. A thumbpiece is slidably disposed within a longitudinal arm member which moves in an arcuate path. Placing his or her thumb in the thumbpiece, a user controls the horizontal positioning of a cursor by moving the arm member along the arcuate path. Vertical positioning of the cursor is controlled by sliding the thumbpiece along the length of the arm member. Trigger functions are implemented by exerting a downward force on the thumbpiece. Since the downward force used to implement the trigger function is orthogonal to motions used to control positioning of the cursor irrespective of the particular positions of the arm member and thumbpiece, the disclosed interface control prevents a user from inadvertently altering the positioning of the cursor during implementation of the trigger function. The arm member and sliding thumbpiece emulate the natural pivoting and curling/extending motions of the thumb, thereby resulting in a precise, easy to use, and ergonomically superior interface control.

I hereby certify that this correspondence is being deposited with the United States Postal Service as as "Express Mail Post Office to Addressee" service under 37 CFR §1.10, Mailing Label Number EJ133931024US, addressed to the Assistant Commissioner for Patents, Washington, DC 20231 on SEPT. 8, 1999.

By JAMES R. RIEGEL

PATENT

Attorney Docket No.: IMM1P060.RE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re reissue application of:	
Craig F. Culver	Examiner: Unassigned
Serial No.: Unassigned	Art Unit: Unassigned
Filed: Unassigned	**REISSUE DECLARATION UNDER 37 C.F.R. § 1.175(a) AND POWER OF ATTORNEY BY INVENTORS**
For: INTERFACE CONTROL	

The Honorable Commissioner of Patents and Trademarks
Washington, D. C. 20231

Sir:

I, Craig F. Culver, state and declare the following:

1. I am a citizen of the United States of America residing at 201 Ware Road, Woodside, CA 94062.

2. The entire right, title and interest to U.S. Patent No. 5,666,138, issued September 9, 1997 is vested in Immersion Corp., a California corporation having a regular and established place of business at 2158 Paragon Dr., San Jose, CA 95131, except for an exclusive license back to Craig F. Culver for all products outside the force feedback field of use.

3. I verily believe myself to be the original, first, and sole inventor of the invention described and claimed in the above-identified United States Letters Patent and in the present application for reissue of the above-identified United States Letters Patent.

4. I have reviewed and understand the contents of the attached specification and claims, including the new claims as presented in this application for reissue of the original Letters Patent.

5. I acknowledge the duty to disclose information of which I am aware and which is material to the examination of this application for reissue of the original Letters Patent in accordance with 37 C.F.R. § 1.56, including information which was discovered between the filing date of United States Patent Application Serial No. 08/343,300 that matured into the Letters Patent for which reissue is being sought and the filing date of this application for reissue.

6. I verily believe that the original Letters Patent is partly or wholly inoperative or invalid by reason of my claiming more or less than I had a right to claim in the original Letters Patent, and that the errors described below which render said Letters Patent so partly or wholly inoperative or invalid occurred through inadvertence and/or omission without any fraudulent or deceptive intent on my part.

7. More specifically, I believe that the original Letters Patent for which I seek reissue claims more or less than I had the right to claim for the following reasons:

7.1. Column 4, lines 31-33, 45-47, 52-55, and 58-61 and several other columns of the original Letters Patent include what I believe to be an accurate and proper characterization of a force feedback device including several features, reproduced below:

> First sensor 26 ... is coupled to arm member 20 and senses the angular rotation of arm member 20 about point 22...Thumbpiece 28... is slidably mounted within cavity 30 of arm member 20 and may slide along the length of arm member 20... Curved contact surface 38, which is provided on a top surface of thumbpiece 28, engages the thumb of a user operating hand-held interface control 10 (FIGS. 2, 3A, and 3B)... Second sensor 42, which is disposed within arm member 20, detects the linear movement of shaft 40 (and thus the linear movement of thumbpiece 28) relative to sensor 42...When a user exerts a downward pressure upon thumbpiece 28, third sensor 44

engages base plate 14 and in response thereto generates a trigger control signal...

A user cradles hand-held interface control 10 in the palm of his or her hand, positioning his fingers along the underside of bottom plate 14 and resting his thumb on curved contact surface 38 of thumbpiece 28, as shown in FIG. 5. Using only his thumb, the user may control the horizontal and vertical positioning of, for instance, a cursor on a display screen, as well as implement various related functions (such as seleting options from a pull-down menu)...

The downward pressure exerted by the thumb to implement a trigger control signal is always orthogonal to the thumb motions used to control horizontal and vertical positioning, regardless of the angular position of arm member 20 or the linear position of thumbpiece 28... Indeed, interface controls 10 and 50 are suitable for one-handed operation, thereby leaving the user's other hand free to perform other tasks...

Interface controls 10 and 50 are ideal for replacing the mouse or trackball in computer software applications such as word processing, databases, and spreadsheets. For instance, interface control 50 of FIG. 6... is well suited for use with video games. As described above, thumbpiece 28 may be used to control the positioning of a character in the video game...

Embodiments of the present invention may also be incorporated into conventional two-handed video game controllers (see FIG. 1) to provide a superior video game interface control. For example, positioning control keys 2a, 2b, 2c, and 2d (FIG. 1) may be replaced by interface control 10...

Various forms of feedback may be added to the above described embodiments to provide a user with additional information about the particular application he or she is controlling, as described

below in reference to FIGS. 11 and 12. For instance, arm member 20 of interface control 10 ... may be fitted with a first actuator that in response to a first feedback signal prevents arm member 20 from further pivoting in one or both directions or, in the alternative, alters the frictional contact between arm member 20 and base plate 14 so as to alter the ease with which arm member 20 pivots...

Arm member 20 of interface control 80 has coupled thereto electromagnetic coil 82 which, in turn, is wound around a conventional ferrous core (not shown)...In other words, coil 82, shaft 84, and armature 88 act as a magnetically activated brake. Varying levels of feedback current will result in proportionally varying levels of drag. This brake may be implemented to simulate detents, stops, or other forms of reflective feedback.

In a similar manner, a second actuator may be provided that in response to a second feedback signal inhibits the movement of thumbpiece 28 along arm member 20... The embodiments described above...would, for instance, be especially well suited for use with applications in which it is desirable to preclude a user from selecting certain options or moving a cursor into certain areas... Thus, the feedback signals, by restraining or even preventing (1) arm member 20 from pivoting about point 22 and/or (2) thumbpiece 28 from sliding along arm member 20 directly inform the user he can no longer move in that direction. In a similar manner, an additional actuator may be contained within third sensor 44 (see FIG. 3A) to preclude activation of trigger functions at certain predetermined character positions...

In other applications, interface control 80 (FIG. 11) may be used to facilitate the selection of options or icons. As the user moves the cursor or pointer over an icon displayed on a screen, feedback signals generated by the application may simulate a detent by increasing the frictional coupling between arm member 20 and sidewall 16b and between thumbpiece 28 and arm member 20, as

described above with reference to FIGS. 11 and 12, when the cursor or pointer is positioned near or overlaps certain icons displayed on the screen. This simulated detent varies the amount of force the user must exert to effect further positioning changes in certain directions, i.e., the detent may either make it easier or harder for the user to cause the cursor to pass across the icon. In this manner, the user can "feel" when he or she has reached a particular icon (or any other specific screen location). This simulated detent may be deactivated when, for instance, the icon has been selected or when the cursor has passed over the icon.

The actuators discussed above may comprise a solenoid, a servomotor, or any other suitable device known in the art which generates a force in response to electric signals. The actuators may also employ shape-memory alloys, piezo ceramics, or electro-rheological compounds. Further, motor-type actuators may be employed to augment or restrain motion.

In other embodiments, the actuators discussed above may used to activate and deactivate electrically controlled detents so as to provide tactile click stops in the pivoting motion of arm member 20 (FIG. 2) about point 22 or in the linear motion of thumbpiece 28 along arm member 20. These detents may be logically correlated with specific targets or options on a display screen such that once a particular option is selected, its corresponding detent is electrically deactivated...

7.2. The absence in the original Letters Patent of an independent claim in which a handheld force feedback device for providing positioning signals to a computer for positioning a displayed cursor, where the device includes a housing able to be held by the hand of a user, a user manipulatable member moveable by the user's thumb in two dimensions, at least one sensor for sensing movement of the user manipulatable member, at least one actuator for providing force in at least one of the dimensions of the user manipulatable member to facilitate the selection of displayed

options or icons based on feedback signals from an application, and a trigger sensor for detecting a trigger command from the user which includes moving the member approximately orthogonally to the two dimensions, without the recital of specific elements such as a rotatable arm member and slidable contact member, such as is provided in new claim 24 below, resulted in the original Letters Patent claiming less than the applicant had a right to claim. At the time of drafting and prosecution of the application that matured into the original Letters Patent, I did not perceive that such a claim could be made. I recently reviewed the claims of the original Letters Patent and realized that there was an issue that I may have claimed less than I had a right to claim, and I have been consulting with my counsel to determine whether a reissue should be filed to cure this error.

7.3. To cure the aforementioned error of inadvertent omission, I therefore request the addition of a claim such as claim 24 below:

> 24. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a display device, said device comprising:
>
> a support housing able to be held by a hand of a user;
>
> a user manipulatable member engageable and moveable by a thumb of said user in two dimensions relative to said support housing while said support housing is held by said hand of said user, wherein said movement in said two dimensions positions said cursor in two screen dimensions on said display device;
>
> at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two dimensions, said sensor providing positioning signals which control said positioning of said cursor on said display device;
>
> at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in at least one of said dimensions of said user manipulatable member, wherein said force facilitates the selection of options or icons displayed on said display device based on feedback signals generated by an application running on said computer; and

a trigger sensor for detecting a trigger command from said user, said trigger command including moving said user manipulatable member approximately orthogonally to said two dimensions.

7.4. The addition of such a claim would cure my error of inadvertent omission by reciting a hand-held force feedback device that includes a user manipulatable member moveable in two dimensions, a sensor, at least one actuator for outputting a force facilitating object selection, and a trigger sensor, without the inclusion of elements which are not required to distinguish the invention over the prior art. In particular, this claim differs from the independent claims of the present Letters Patent by reciting, among other elements, a user manipulatable member moveable in two dimensions relative to a handheld housing, a sensor for sensing motion in at least one of those dimensions, at least one actuator for outputting a force in at least one of those dimensions for facilitating selection of displayed options or icons, and a trigger sensor for detecting a trigger command that moves the user manipulatable member approximately orthogonally to the two dimensions, without the inclusion of other elements such as a rotatable arm member and slidable contact member, which are now understood not to be required to distinguish the invention recited in claim 24.

7.5. New dependent claims 25 and 26 would cure the inadvertent omission of a claim which recites the force feedback device of claim 24 where the two dimensions are provided substantially in a single plane, and where the motion of the user manipulatable member is orthogonal to a plane defined by the planar dimensions.

7.6. New dependent claim 27 would cure the inadvertent omission of a claim which recites the force feedback device of claim 24 and which recites that two actuators are provided to provide force in the two dimensions.

7.7. New dependent claims 28 and 29 would cure the inadvertent omission of claims which recite the force feedback device of claim 24 and which recite that the user manipulatable member is coupled to an arm member having rotary motion about a pivot point and the actuator is coupled to the arm member to output forces about the pivot point, and that the arm member is limited to an arcuate path of less than ninety degrees.

7.8. New dependent claims 30 and 31 would cure the inadvertent omission of claims which recite the force feedback device of claim 28 and which recites that the first actuator is grounded to the housing and the second actuator is carried by the arm member, and where the user manipulatable member is a sliding contact member which can be moved in a linear dimension approximately perpendicular to an axis of rotation of the arm member and in substantially the same plane as the rotary motion.

7.9. New dependent claim 32 would cure the inadvertent omission of a claim which recites the force feedback device of claim 24 and which recites that the cursor can be positioned and displayed icons or options can be selected by a single hand of the user.

7.10. New dependent claim 33 would cure the inadvertent omission of a claim which recites the force feedback device of claim 24 and which recites that the actuator is one of a motor, a brake, and a solenoid.

7.11. New dependent claims 34 and 35 would cure the inadvertent omission of claims which recite the force feedback device of claim 24 and which recite that the user manipulatable member is coupled to a centering spring return that causes a bias on the user manipulatable member to return to a center position after it has been moved from the center position, and where a centering spring bias on said user manipulatable member may be electrically actuated by a signal received from the computer, allowing the force feedback device to have a centering mode and a non-centering mode, selected by the computer.

7.12. New dependent claims 36, 37, and 38 would cure the inadvertent omission of claims which recite the force feedback device of claim 24 and which recite that the cursor can be used to select an icon, the trigger command selects the icon when the cursor is positioned over the icon, that the actuator outputs a force to augment or restrain motion of the cursor on the screen, and that the image is a video game character.

7.13. New dependent claim 39 would cure the inadvertent omission of a claim which recites the force feedback device of claim 24 and a trigger actuator for causing

resistance to the motion of the trigger command by the user based on a feedback signal from the computer.

7.14. New dependent claim 40 would cure the inadvertent omission of a claim which recites the force feedback device of claim 24 and at least one additional control provided on the housing and operable by a different hand of the user.

7.15. New dependent claims 41, 42, and 43 would cure the inadvertent omission of claims which recite the force feedback device of claim 24 and which recite that the actuator outputs detents when the cursor overlaps or is positioned near an icon displayed on the screen, that the detents provide tactile click stops correlated with targets or options displayed on the screen, and that a detent correlated with a target or option is deactivated once the target or option is selected by the user using the force feedback device.

7.16. New dependent claims 44 and 45 would cure the inadvertent omission of claims which recite the force feedback device of claim 41 and which recite that the user selects the target or option by causing a trigger signal to be sent to the computer, the trigger signal caused by a pressing motion of the user manipulatable member, and that the detents are output for use in a word processor or spreadsheet program provided on the computer.

7.17. I further believe that the absence in said Letters Patent of an independent claim in which a force feedback device for providing positioning signals to a computer for manipulating a displayed image, where the device includes a housing, a user manipulatable member moveable by the user's digit in two degrees of freedom, at least one sensor for sensing movement of the user manipulatable member in the two degrees of freedom, at least one computer controlled brake for providing drag in at least one of the degrees of freedom, and a trigger sensor for detecting a trigger command from the user which includes a pressing motion by the user's digit causing the member to move in a different degree of freedom, without the recital of specific elements such as a rotatable arm member and slidable contact member, such as is provided in new 46 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters

Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, I did not perceive that a device that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-23 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, I therefore request the addition of a claim such as claim 46 below:

> 46. A force feedback device coupled to a computer for providing positioning signals to said computer for manipulating an image displayed on a screen by said computer, said device comprising:
>
> a support housing;
>
> a user manipulatable member coupled to said housing and engageable and moveable by one or more digits of said user in two degrees of freedom relative to said housing, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;
>
> at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said sensor providing positioning signals which control positioning of said image on said screen by said computer;
>
> at least one computer controlled brake coupled to said user manipulatable member, wherein said brake provides a drag in at least one of said degrees of freedom of said user manipulatable member; and
>
> a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion by said digit causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

7.18. New dependent claim 47 would cure the inadvertent omission of a claim which recites the force feedback device of claim 46and which recites that the housing is able to be held and operated by a single hand of a user.

7.19. New dependent claims 48 and 49 would cure the inadvertent omission of claims which recite the force feedback device of claim 46 and which recite that the

other of the two degrees of freedom is a linear degree of freedom, and that the two degrees of freedom are approximately in the same plane.

7.20. New dependent claim 50 would cure the inadvertent omission of a claim which recites the force feedback device of claim 46 and which recites that the brake is a first brake providing a drag in a first of the two degrees of freedom, and further comprising a second computer controlled brake coupled to said user manipulatable member, where the second brake provides a drag in a second one of the degrees of freedom.

7.21. New dependent claims 51 and 52 would cure the inadvertent omission of claims which recite the force feedback device of claim 50 and which recite that the user manipulatable member is coupled to an arm member having rotary motion about a pivot point, where the first brake is coupled to the arm member to output forces about the pivot point, and that the user manipulatable member is a sliding member which can be moved along at least a portion of the arm member in a linear degree of freedom, where the second brake outputs forces in the linear degree of freedom.

7.22. New dependent claims 53 and 54 would cure the inadvertent omission of claims which recite the force feedback device of claim 46 and which recite that the cursor can be used to select an icon displayed on the screen, where the trigger command selects the icon when the cursor is positioned over the icon, and that the brake outputs a force controlled by the computer to provide tactile clicks correlated with targets or options displayed on the screen.

7.23. New dependent claim 55 would cure the inadvertent omission of a claim which recites the force feedback device of claim 46 and which recites that the device is provided in an automobile dashboard or automobile steering wheel.

7.24. New dependent claims 56 and 57 would cure the inadvertent omission of claims which recite the force feedback device of claim 46 and which recite that the brake includes an electromagnetic coil, and that the brake employs an eletro-rheological compound.

7.25. New dependent claims 48 and 49 would cure the inadvertent omission of claims which recite the force feedback device of claim 46 and which recite that the handle is capable of moving in only two degrees of freedom, and that the two degrees of freedom are linear degrees of freedom.

7.26. I further believe that the absence in said Letters Patent of an independent claim reciting a method for providing positioning signals from a user to a computer to manipulate a displayed cursor, including providing a handheld force feedback device including a thumb member moveable by a user in two degrees of freedom, sensing movement of the thumb member to provide positioning signals, and providing a drag in the two degrees of freedom using at least one braking actuator to facilitate selection of a displayed icon or option, claimed without the inclusion of other elements included in claims 1-24 of the original patent, such as is provided in new claim 58 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, I did not perceive that a method that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-23 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, I therefore request the addition of a claim such as claim 58 below:

> 58. A method for providing positioning signals to a computer from a user for manipulating a displayed cursor on a screen and for providing force feedback to said user, said method comprising:
>
> providing a handheld force feedback device coupled to said computer, said handheld force feedback device including a thumb member engageable and moveable by a thumb of said user in two degrees of freedom while said device is held by said hand of said user;
>
> sensing movement of said thumb member in said two degrees of freedom using at least one motion sensor and providing positioning signals to said computer in accordance with said sensed movement, wherein said positioning signals are used by said host computer to move a cursor displayed on a screen in two dimensions of said screen; and

providing a drag in said two degrees of freedom of said thumb member using at least one braking actuator coupled to said thumb member, wherein said drag facilitates selection of an icon or option displayed on said screen by said cursor.

7.27. New dependent claim 59 would cure the inadvertent omission of a claim which recites the method of claim 58 and which recites detecting a trigger command from said user including a pressing motion of the thumb member, where the trigger command is sent to the computer to be used to select an option or icon displayed on the screen with the cursor.

7.28. New dependent claims 60 and 61 would cure the inadvertent omission of claims which recite the method of claim 58 and which recites that the two degrees of freedom are substantially in a single plane, and that one of the degrees of freedom is a rotary degree of freedom and another of the degrees of freedom is a linear degree of freedom.

7.29. New dependent claim 62 would cure the inadvertent omission of a claim which recites the method of claim 58 and which recites that the brakes output drag to hinder motion of a rotating member coupled to the thumb member and hinder a sliding motion of the thumb member.

7.30. Column 11, lines 42-48 and 55-61 of the original Letters Patent include what I believe to be an accurate and proper characterization of a force feedback device including a spring mechanism, reproduced below:

> Embodiments of the present invention may also be equipped with a spring return mechanism. With reference to interface control 10 (FIG. 2), a centering spring may be coupled to arm member 20 which causes arm member 20 to return to its center position whenever arm member 20 has deviated from the center position by exerting pressure on arm member 20...The centering spring may also be electrically actuated by an external signal from the interfaced device (i.e., computer, video game, and so on). Inclusion of such an electrically

actuated spring allows the interfaced device to switch the controller between two modes of operation (spring centering and non-centering), as the particular application may require.

7.31. I further believe that the absence in said Letters Patent of an independent claim reciting a handheld force feedback device for providing positioning signals to a computer for positioning a displayed cursor, including a housing, a user manipulatable member moveable by a digit of a user in two degrees of freedom, where one of the degrees of freedom is rotary, a spring return mechanism to provide a centering bias on the member toward a center position of the rotary degree of freedom, at least one sensor for providing positioning signals, at least one actuator for providing a force in one of said degrees of freedom, and a trigger sensor for detecting a trigger command from the user, including a pressing motion in a different degree of freedom, claimed without the inclusion of other elements included in claims 1-24 of the original patent, such as is provided in new claim 63 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, I did not perceive that a device that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-23 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, I therefore request the addition of a claim such as claim 63 below:

63. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a screen, said device comprising:

a support housing;

a user manipulatable member coupled to said housing and engageable and moveable by a digit of said user in two degrees of freedom relative to said housing while said housing is held by said hand of said user, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

a spring return mechanism coupled to said user manipulatable member to provide a centering bias on said user manipulatable member toward a center position of said rotary degree of freedom when said user manipulatable member has been moved from said center position;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said sensor providing positioning signals which control said positioning of said cursor on said screen;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

7.32. New dependent claim 64 would cure the inadvertent omission of a claim which recites the force feedback device of claim 63 and which recites that the spring return mechanism is electrically actuated by an external signal received from the computer, allowing the spring return mechanism to be selectively applied in a centering mode and allowing the spring return mechanism to have no effect in a non-centering mode.

7.33. New dependent claim 65 would cure the inadvertent omission of a claim which recites the force feedback device of claim 64 and which recites that the external signal is controlled by a video game running on the computer.

7.34. New dependent claim 66 would cure the inadvertent omission of a claim which recites the force feedback device of claim 64 and which recites that the spring return mechanism is coupled to a pivotable arm member providing the rotary degree of freedom, and further comprising a centering spring coupled to the user manipulatable member to provide a centering bias in another of the two degrees of freedom.

7.35. Column 9, lines 6-15 of the original Letters Patent include what I believe to be an accurate and proper characterization of a force feedback device for use in an automobile, reproduced below:

> The above described interface controls may be mounted in virtually any enclosure, including (but not limited to) control panels, automobile dashboards, steering wheels, or handgrips of other interface controls. For instance, in one such embodiment, base plate 14 (FIG. 2) may be disposed within the handgrip portion of a floor-mounted lever arm control, i.e., a transmission selector in a vehicle, to provide users with a superior means to control such things as the vehicle's navigation system or communications with the vehicle's on-board computer system.

7.36. I further believe that the absence in said Letters Patent of an independent claim in which a force feedback control provided in an automobile and coupled to an on-board vehicle computer system for providing input to the computer system, including a user manipulatable member, sensor, actuator, and trigger sensor, claimed without the inclusion of other elements included in claims 1-23 of the original patent, such as is provided in new claim 67 below, is an error of inadvertent omission that occurred during the drafting and prosecution of the application that matured into the present Letters Patent. At the time of drafting and prosecution of the application that matured into the present Letters Patent, I did not perceive that a device that includes the above elements should be claimed independently, without the inclusion of other elements such as are included in claims 1-23 of the present Letters Patent. To cure the aforementioned error of inadvertent omission, I therefore request the addition of a claim such as claim 67 below:

> 67. A force feedback control provided in an automobile and coupled to an on-board vehicle computer system for providing input to said computer system, said control comprising:
>
> a user manipulatable member provided in an automobile dashboard, said member engageable and moveable by a digit of said user in two degrees

of freedom relative to said dashboard, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said input to said computer system based on positioning signals provided by said sensor;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

7.37. New dependent claim 68 would cure the inadvertent omission of a claim which recites the force feedback device of claim 67 and which recites that the user manipulatable member is manipulated by the user to provide communication with the on-board computer system.

7.38. New dependent claim 69 would cure the inadvertent omission of a claim which recites the force feedback device of claim 67 and which recites that the input to the computer system controls a vehicular navigation system.

7.39. New dependent claim 70 would cure the inadvertent omission of a claim which recites the force feedback device of claim 67 and which recites that the two degrees of freedom of the user manipulatable member define a plane.

7.40. New dependent claim 71 would cure the inadvertent omission of a claim which recites the force feedback device of claim 67 and which recites that the trigger degree of freedom is orthogonal to the plane.

7.41. New dependent claim 72 would cure the inadvertent omission of a claim which recites the force feedback device of claim 67 and which recites that the actuator is a motor.

7.42. New dependent claim 73 would cure the inadvertent omission of a claim which recites the force feedback device of claim 67 and which recites that the actuator is a passive brake.

7.43. I hereby appoint the following attorneys and agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

James R. Riegel, Reg. No. 36,651; Paul L. Hickman, Reg. No. 28,516; L. Keith Stevens, Reg. No. 32,632; Brian R. Coleman, Reg. No. 39,145; Michael E. Melton, Reg. No. 32,276; Jerry Wei, Reg. No. 43,247; Robert D. Hayden, Reg. No. 42,645; Kevin J. Zilka (Reg. No. 41,429); and Dominic M. Kotab, Reg. No. 42,762.

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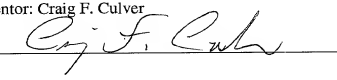
9. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Full name of sole inventor: Craig F. Culver

Inventor's signature:  .

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NEW CLAIMS

24. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a display device, said device comprising:

a support housing able to be held by a hand of a user;

a user manipulatable member engageable and moveable by a thumb of said user in two dimensions relative to said support housing while said support housing is held by said hand of said user, wherein said movement in said two dimensions positions said cursor in two screen dimensions on said display device;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two dimensions, said sensor providing positioning signals which control said positioning of said cursor on said display device;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in at least one of said dimensions of said user manipulatable member, wherein said force facilitates the selection of options or icons displayed on said display device based on feedback signals generated by an application running on said computer; and

a trigger sensor for detecting a trigger command from said user, said trigger command including moving said user manipulatable member approximately orthogonally to said two dimensions.

25. A force feedback device as recited in claim 24 wherein said two dimensions are provided substantially in a single plane.

26. A force feedback device as recited in claim 25 wherein said motion of said user manipulatable member is orthogonal to a plane defined by said planar dimensions.

27. A force feedback device as recited in claim 24 wherein said at least one actuator is a first actuator, and further comprising a second actuator coupled to said

user manipulatable member, wherein said second actuator provides a force in the other of said dimensions of said user manipulatable member.

28. A force feedback device as recited in claim 24 wherein said user manipulatable member is coupled to an arm member having rotary motion about a pivot point to provide motion in one of said two dimensions, wherein said actuator is coupled to said arm member to output forces about said pivot point.

29. A force feedback device as recited in claim 28 wherein said rotary motion of said arm member is limited to an arcuate path of less than ninety degrees.

30. A force feedback control device as recited in claim 28 further comprising a second actuator, and wherein said first actuator is grounded to said housing and wherein said second actuator is carried by said arm member.

31. A force feedback device as recited in claim 28 wherein said user manipulatable member is a sliding contact member which can be moved in a linear dimension approximately perpendicular to an axis of rotation of said arm member and in substantially the same plane as said rotary motion, thereby providing said motion in one of said two dimensions.

32. A force feedback device as recited in claim 24 wherein said cursor can be positioned and displayed icons or options can be selected by a single hand of said user.

33. A force feedback device as recited in claim 24 wherein said at least one actuator is one of a motor, a brake, and a solenoid.

34. A force feedback device as recited in claim 24 wherein said user manipulatable member is coupled to a centering spring return that causes a bias on said user manipulatable member to return to a center position after it has been moved from said center position.

35. A force feedback device as recited in claim 24 wherein a centering spring bias on said user manipulatable member may be electrically actuated by a signal received from said computer, allowing said force feedback device to have a centering mode and a non-centering mode, selected by said computer.

36. A force feedback device as recited in claim 24 wherein said cursor can be used to select an icon, wherein said trigger command selects said icon when said cursor is positioned over said icon.

37. A force feedback device as recited in claim 36 wherein said at least one actuator outputs a force to augment or restrain motion of said cursor on said screen.

38. A force feedback device as recited in claim 24 wherein said image is a video game character.

39. A force feedback device as recited in claim 24 further comprising a trigger actuator for causing resistance to said motion of said trigger command by said user based on a feedback signal from said computer.

40. A force feedback device as recited in claim 24 further comprising at least one additional control provided on said housing and operable by said user, wherein said additional control is operated by a different hand of said user than said hand operating said user manipulatable member.

41. A method as recited in claim 24 wherein said at least one actuator outputs detents when said cursor overlaps or is positioned near an icon displayed on said screen.

42. A method as recited in claim 41 wherein detents provide tactile click stops correlated with targets or options displayed on said screen.

43. A method as recited in claim 42 wherein a detent correlated with a target or option is deactivated once said target or option is selected by said user using said force feedback device.

44. A method as recited in claim 41 wherein said user selects said target or option by causing a trigger signal to be sent to said computer, said trigger signal caused by a pressing motion of said user manipulatable member.

45. A method as recited in claim 41 wherein said detents are output for use in a word processor or spreadsheet program provided on said computer.

46. A force feedback device coupled to a computer for providing positioning signals to said computer for manipulating an image displayed on a screen by said computer, said device comprising:

a support housing;

a user manipulatable member coupled to said housing and engageable and moveable by one or more digits of said user in two degrees of freedom relative to said

housing, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said sensor providing positioning signals which control positioning of said image on said screen by said computer;

at least one computer controlled brake coupled to said user manipulatable member, wherein said brake provides a drag in at least one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion by said digit causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

47. A force feedback device as recited in claim 46 wherein said housing is able to be held and operated by a single hand of a user.

48. A force feedback device as recited in claim 46 wherein the other of said two degrees of freedom is a linear degree of freedom and wherein said rotary degree of freedom allows a pivoting motion of said digit of said user.

49. A force feedback device as recited in claim 47 wherein said two degrees of freedom are approximately in the same plane.

50. A force feedback device as recited in claim 46 wherein said at least one brake is a first brake providing a drag in a first of said two degrees of freedom, and further comprising a second computer controlled brake coupled to said user manipulatable member, wherein said second brake provides a drag in a second one of said degrees of freedom of said user manipulatable member.

51. A force feedback device as recited in claim 50 wherein said user manipulatable member is coupled to an arm member having rotary motion about a pivot point, wherein said first brake is coupled to said arm member to output forces about said pivot point.

52. A force feedback device as recited in claim 51 wherein said user manipulatable member is a sliding member which can be moved along at least a portion of said arm member in a linear degree of freedom, and wherein said second brake outputs forces in said linear degree of freedom.

53. A force feedback device as recited in claim 46 wherein said cursor can be used to select an icon displayed on said screen, wherein said trigger command selects said icon when said cursor is positioned over said icon.

54. A force feedback device as recited in claim 46 wherein said brake outputs a force controlled by said computer to provide tactile clicks correlated with targets or options displayed on said screen.

55. A force feedback device as recited in claim 46 wherein said device is provided in an automobile dashboard or automobile steering wheel.

56. A force feedback device as recited in claim 46 wherein said at least one brake includes an electromagnetic coil.

57. A force feedback device as recited in claim 46 wherein said at least one brake employs an electro-rheological compound.

58. A method for providing positioning signals to a computer from a user for manipulating a displayed cursor on a screen and for providing force feedback to said user, said method comprising:

providing a handheld force feedback device coupled to said computer, said handheld force feedback device including a thumb member engageable and moveable by a thumb of said user in two degrees of freedom while said device is held by said hand of said user;

sensing movement of said thumb member in said two degrees of freedom using at least one motion sensor and providing positioning signals to said computer in accordance with said sensed movement, wherein said positioning signals are used by said host computer to move a cursor displayed on a screen in two dimensions of said screen; and

providing a drag in said two degrees of freedom of said thumb member using at least one braking actuator coupled to said thumb member, wherein said drag facilitates selection of an icon or option displayed on said screen by said cursor.

59. A method as recited in claim 58 further comprising detecting a trigger command from said user, said trigger command including a pressing motion of said thumb member, wherein said trigger command is sent to said computer to be used to select an option or icon displayed on said screen with said cursor.

60. A method as recited in claim 58 wherein said two degrees of freedom are substantially in a single plane.

61. A method as recited in claim 58 wherein one of said degrees of freedom is a rotary degree of freedom and another of said degrees of freedom is a linear degree of freedom.

62. A method as recited in claim 58 wherein said brakes output drag to hinder motion of a rotating member coupled to said thumb member and hinder a sliding motion of said thumb member.

63. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a screen, said device comprising:

a support housing;

a user manipulatable member coupled to said housing and engageable and moveable by a digit of said user in two degrees of freedom relative to said housing while said housing is held by said hand of said user, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

a spring return mechanism coupled to said user manipulatable member to provide a centering bias on said user manipulatable member toward a center position of said rotary degree of freedom when said user manipulatable member has been moved from said center position;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said

sensor providing positioning signals which control said positioning of said cursor on said screen;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

64. A force feedback device as recited in claim 63 wherein said spring return mechanism is electrically actuated by an external signal received from said computer, allowing said spring return mechanism to be selectively applied in a centering mode and allowing said spring return mechanism to have no effect in a non-centering mode.

65. A force feedback device as recited in claim 64 wherein said external signal is controlled by a video game running on said computer.

66. A force feedback device as recited in claim 64 wherein said spring return mechanism is coupled to a pivotable arm member providing said rotary degree of freedom, and further comprising a centering spring coupled to said user manipulatable member to provide a centering bias in another of said two degrees of freedom.

67. A force feedback control provided in an automobile and coupled to an on-board vehicle computer system for providing input to said computer system, said control comprising:

a user manipulatable member provided in an automobile dashboard, said member engageable and moveable by a digit of said user in two degrees of freedom relative to said dashboard, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said input to said computer system based on positioning signals provided by said sensor;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

68. A force feedback control as recited in claim 67 wherein said user manipulatable member is manipulated by said user to provide communication with said on-board computer system.

69. A force feedback control as recited in claim 67 wherein said input to said computer system controls a vehicular navigation system.

70. A force feedback control as recited in claim 67 wherein said two degrees of freedom of said user manipulatable member define a plane.

71. A force feedback control as recited in claim 67 wherein said trigger degree of freedom is orthogonal to said plane.

72. A force feedback control as recited in claim 67 wherein said actuator is a motor.

73. A force feedback control as recited in claim 67 wherein said actuator is a passive brake.

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on SEPT. 8, 1999.

By _____
James R. Riegel

PATENT

Attorney Docket No.: IMM1P060.RE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re reissue application of:	
CRAIG F. CULVER	Examiner: Unassigned
Serial No.: Unassigned	Art Unit: Unassigned
Filed: Unassigned	**OFFER TO SURRENDER LETTERS PATENT**
For: INTERFACE CONTROL	

The Honorable Commissioner of Patents and Trademarks
Washington, D. C. 20231

Sir:

The undersigned assignee of the accompanying reissue application for the reissue of Letters Patent 5,666,138, entitled INTERFACE CONTROL, issued September 9, 1997, of which Immersion Corporation is the sole owner by assignment and on whose behalf and with whose assent the accompanying application is made, hereby offers to surrender said Letters Patent. A Request for Abstract of Title is enclosed herewith.

Date: 9/7/99

By: _____

Name: Louis B. Rosenberg

Title: President

P.O. Box 52037
Palo Alto, CA 94303-0746

Tel: (408) 467-1900

I hereby certify that this correspondence is being deposited with the United States Postal Service as "Express Mail Post Office to Addressee" service under 37 CFR §1.10, Mailing Label Number **EJ133931024US**, addressed to the Assistant Commissioner for Patents, Washington, DC 20231 on September 08, 1999

By _____
James R. Riegel

PATENT

Attorney Docket No.: IMM1P060.RE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re reissue application of:

CRAIG F. CULVER

Serial No.: Unassigned

Filed: Unassigned

For: INTERFACE CONTROL

Examiner: Unassigned

Art Unit: Unassigned

REQUEST FOR ABSTRACT OF TITLE AND ASSENT OF ASSIGNEE

The Honorable Commissioner of Patents and Trademarks
Washington, D. C. 20231

Sir:

Please prepare a certified Abstract of Title for the original U.S. Patent No. 5,666,138 for placing in the official file of the reissue application filed herewith. Title is in the name of Immersion Corporation, a California corporation. The chain of title demonstrating this ownership consists of the assignment recorded on November 16, 1998 at Reel No. 9586, Frame No. 0922. A Statement Under 37 C.F.R. § 3.73(b) is submitted herewith.

The Commissioner is hereby authorized to charge the fee of $25.00, required by 37 CFR 1.19(b), to the undersigned's Deposit Account No. 50-0384. Please charge any additional fees or credit overpayment to the above Deposit Account. A duplicate copy of this sheet is enclosed for accounting purposes.

Respectfully submitted,

James R. Riegel
Registration No. 36,651

Assignee Assent and Statement Under 37 C.F.R. § 3.73(b)

The assignee of the above-identified application for reissue, Immersion Corporation, a California corporation, certifies that it is the Assignee of the entire right, title, and interest in the present application for reissue by virtue of the Assignment of U.S. Patent No. 5,666,138 from the inventor to Immersion Corp., which was recorded in the U.S. Patent and Trademark Office at Reel No. 9586, Frame No. 0922.

The undersigned has reviewed all of the documents in the chain of title of the subject U.S. Patent and, to the best of the undersigned's knowledge and belief, title is in the Assignee identified above. The undersigned (whose title is supplied below) is empowered to sign this certificate on behalf of the Assignee.

Assignee hereby consents to the filing of the present reissue application for the reissue of U.S. Patent No. 5,666,138. Assignee hereby assents to the Declaration executed by Craig F. Culver on 9/7/99.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: 9/7/99

By: _____

Name: Louis B. Rosenberg

Title: President

P.O. Box 52037
Palo Alto, CA 94303-0746
Tel: (408) 467-1900

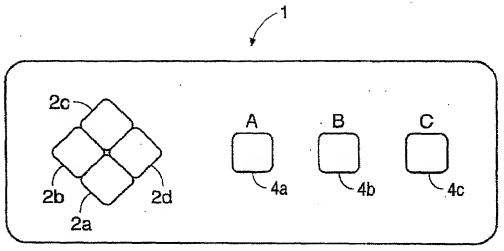

FIG. 1
(PRIOR ART)

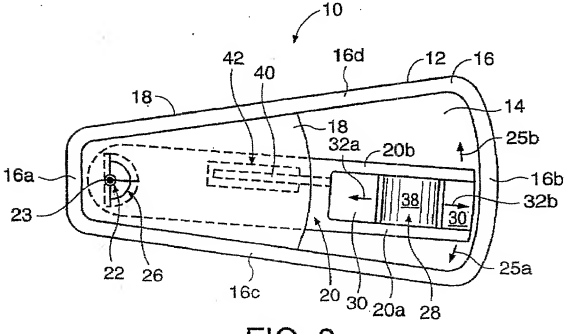

FIG. 2

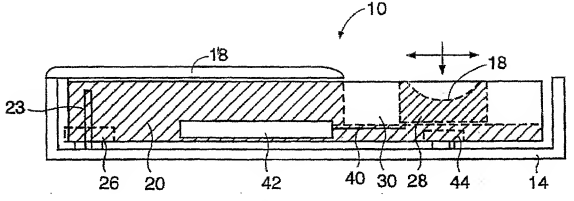

FIG. 3A

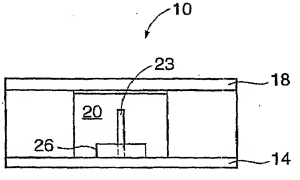

FIG. 3B

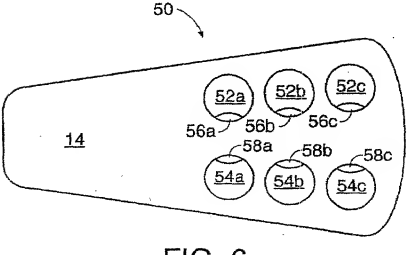

FIG. 6

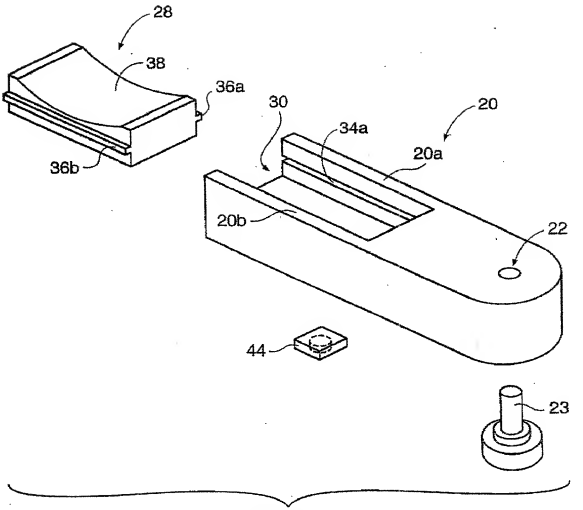

FIG. 4

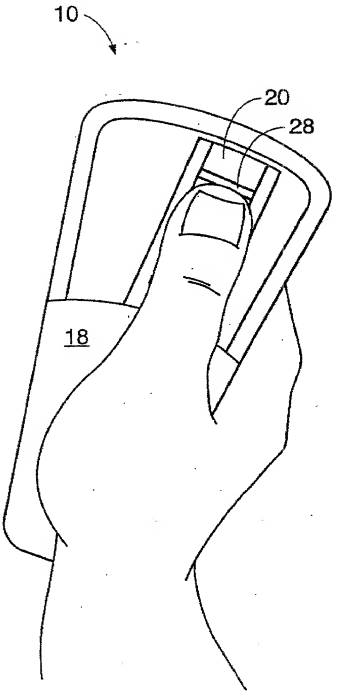

FIG. 5

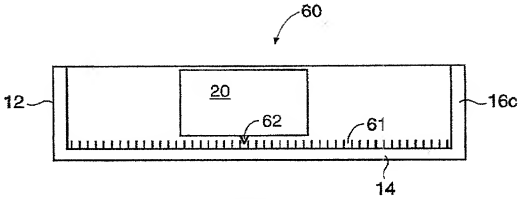

FIG. 7

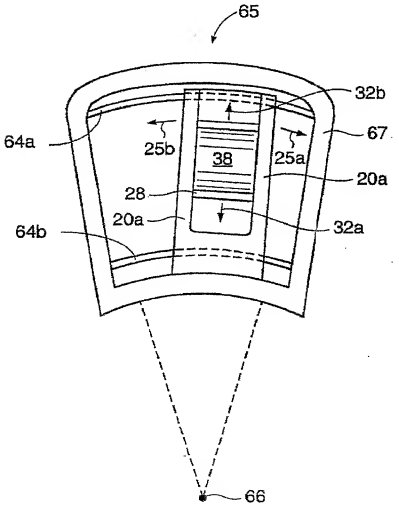

FIG. 8

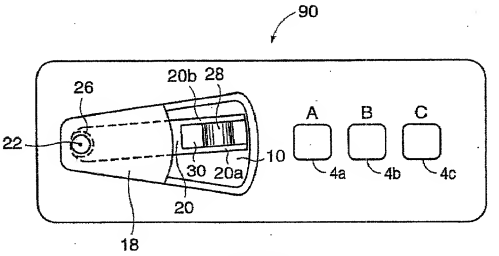

FIG. 9

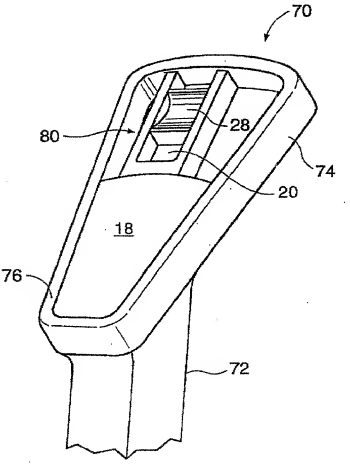

FIG. 10

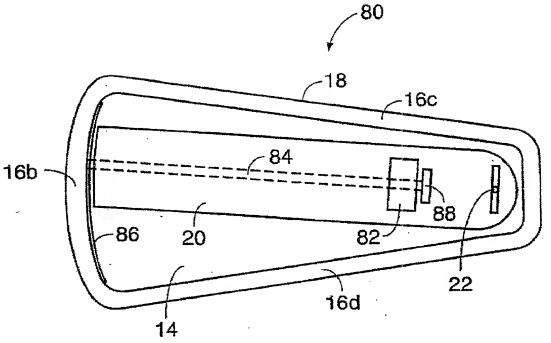

FIG. 11

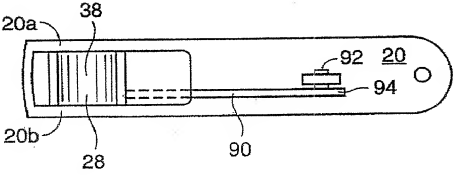

FIG. 12